Next Generation Computational Intelligence Microgrid

Amit Sachan, CResTM

amitsachan55@gmail.com

Positioning of the research

Microgrid is a small power grid that localizes and operates independently of a larger grid to generate, distribute, and control the flow of energy. Microgrids provide efficient and reliable energy services to end users. Microgrid technology employs a wide range of distributed energy technologies including generation, storage, metering and communications. Microgrids manage energy generation, transmission, distribution, and usage on a small scale compared to conventional Microgrid.

It can be used in power generation, transmission, and distribution and consumption applications to meet the Smart Grid's safety, security, reliability, resilience and efficiency needs. We are used for both short-term and long-term load forecasting. This is particularly important, given that population growth is one of the main factors inspiring the industry to produce more power. We can be used to help utilities respond to outages caused by natural disasters, such as storms or downed trees, which impact high-voltage transmission lines. When incorporated in a smart grid, we can detect asymmetric single-phase-to-ground or two-phase-to-ground faults or symmetric three-phase to-ground faults and determine where the faults have occurred in the transmission and distribution system. This is a significant attribute in any power system. We can also be applied in conjunction with sensor networks to monitor power quality. If a power quality issue occurs, the system will alert the administrator, who can then take the steps necessary to address the problem.

To begin to address the large - scale computation, modeling, and data handling challenges of the future grid. This provides the potential for new control approaches and operator tools that can enhance system efficiencies and improve reliability. Finally, models are becoming increasingly essential for improved decision making across the electric system, from resource forecasting to

adaptive real - time controls to on - line dynamics analysis. The importance of data is thus reinforced by their inescapable role in validating, high - fidelity models that lead to deeper system understanding. Traditional boundaries (reflecting geographic, institutional, and market differences) are becoming blurred, and thus, it is increasingly important to address these seams in model formulation and utilization to ensure accuracy in the results and achieve predictability necessary for reliable operations.

Research design & methodology

1- Microgrid Control Software on Computational Architectures: The future Microgrid needs will demand scalability of a kind that only cloud computing can offer. Their research proposal is that there will be Microgrid requirements (real-time, consistency, privacy, security, etc.) that cloud computing cannot currently support and that many of these needs, which are specific to the expected future Microgrid paradigm, will not soon be filled by the cloud industry.

2- Coupled Optimization Models for Planning and Operation of Microgrid on Multiple Scales: This argues that decision processes are predominantly hierarchical and that, models to support such decision processes should also be layered or hierarchical. Ferris contends that, although advice can be provided from the perspective of mathematical optimization on managing complex systems, that advice must be integrated into an interactive debate with informed decision makers. That treating uncertainties in large scale planning projects will become even more critical as the smart grid evolves because of the increase in volatility of both supply and demand. Optimization models with flexible systems design can help address these uncertainties not only during the planning and construction phases, but also during the operational phase of an installed system.

3- Mode Reconfiguration, Hybrid Mode Estimation, and Risk-bounded Optimization for the Next Generation Microgrid: The problems of: 1) increasing the level of automation in the analysis and planning for contingencies in response to unexpected events, and 2) the problem of incorporating considerations of optimality into contingency planning and the overall energy management process. With regard to the first problem, the authors note that, although the level of anticipated automation is still advisory and humans remain in the loop, use of automation would reduce the drudgery and error prone nature of the current labor-intensive approach. Automation

would also guarantee the completeness of an analysis and validity of the contingency plans. With regard to the second problem, the optimization would include establishing risk bounds on actions taken to achieve optimal performance.

4- Model-based Integration Technology for Next Generation Microgrid Simulations: The future Microgrid will require "the efficient integration of digital information, communication systems, real time-data delivery, embedded software and real-time control decision-making." The authors posit that no high-fidelity models are capable of simulating Microgrid interactions with communication and control infrastructure elements for large systems. They also conclude that it is a challenge to model infrastructure interdependencies related to Microgrid, including the networks and software for sensors, controls, and communication.

5- Multi-Dimensional, Multi-Scale Modeling and Algorithms for Next Generation Microgrid: The future Microgrid problems are multi-scale and that there is a need to develop multi-scale simulation models and methods to the level that exists in other engineering disciplines multi-scale, multi-dimensional power system research that are needed to provide a framework for addressing emerging power system problems.

6- Long Term Resource Planning for Microgrid under Uncertainty: Computational tools that are needed in the area of optimization for large-scale planning models that account for uncertainty. The research present, as an example, a proposed model for Microgrid planning that includes linkages with multi-objective planning in the presence of uncertainty where decision makers must balance, for example, sustainability, costs (investment and operational), long-term system resiliency, and solution robustness.

7- Framework for Large-scale Modeling and Simulation of Electricity Systems for Planning, Monitoring, and Secure Operations of Next- generation Microgrid: The context of security-constrained unit commitment and economic dispatch with stochastic analysis, management of massive data sets, and concepts related to large-scale grid simulation optimization, this paper is unique in its exploration of emerging substantive data management issues.

Foresee Results

We assume that designing and building larger and faster computers and faster communications will not be sufficient to solve the electric grid computational problems, although these improvements might ultimately be helpful. Instead, our expectation is that fundamental advances are needed in the areas of algorithms, computer networking and architecture, databases and data over whelm, simulation and modeling, and computational security; perhaps most importantly, these advances must be achievable in a time frame that will be useful to the industry.

1. New algorithms that are scalable and robust for solving large nonlinear mixed-integer optimization problems and methods for efficiently solving (in real-time) large sets of ordinary differential equations with algebraic constraints, including delays, parameter uncertainties, and monitored data as inputs. These new algorithms should accommodate randomness for capturing appropriate notions of security and incorporate recent results on improving deterministic and randomized algorithms for computationally hard problems.
2. A new mathematics for characterizing uncertainty in information created from large volumes of data as well as for characterizing uncertainty in models used for prediction.
3. New methods to enable efficient use of high-bandwidth networks by dynamically identifying only the data relevant to the current information need and discarding the rest. This would be especially useful for wide-area dynamic control where data volume and latency are barriers.
4. New software architectures and new rapid development tools for merging legacy and new code without disrupting operation. Software should be open source, modular, and transparent. Security is a high priority.